Docket No.: PD05962AM

Application for U.S. Patent

IMPROVED CABLE CHANNEL SEARCH SYSTEMS

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TITLE OF THE INVENTION

IMPROVED CABLE CHANNEL SEARCH SYSTEMS

FIELD OF THE INVENTION

The present invention relates generally to receiver systems for channelized networks, and more particularly, to methods and apparatus for selecting a desired channel where the channel plan of the channelized network is unknown.

BACKGROUND OF THE INVENTION

Demand for high-speed Internet access has resulted in utilization of receivers such as cable modems to connect to broadband communications networks, such as cable television (CATV) systems, in various countries. The receiver must operate on broadband communications networks that deliver a multitude of services simultaneously. To keep these services from interfering with each other, the service provider allocates each service a distinct band of frequencies on the broadband network as a channel. A channel plan allocates the channels in the broadband frequency spectrum so that they do not interfere with each other.

Regulatory authorities in many countries and regions can, and do, regulate the channel plans of broadband communications networks. Further, even where differing regulatory authorities do not mandate different channel plans, because broadband communications services are typically using closed systems, broadband communications service providers have great flexibility in how they can allocate channels for their networks. The result is a worldwide multitude of channel plans.

Despite the use of a multitude of different channel plans, it is desirable for efficient and economical manufacture of receivers, to have only a minimal number of receiver designs. Such designs could be used throughout many of these countries and regions despite the differences in frequency allocation and utilization. In addition, it is desired that a limited number of receiver models be manufactured that would work optimally independent of the system in which it is used.

Channel plans define channel allocations by usually defining the center frequency and bandwidth of each channel, and may define the modulation type for the spectrum associated with the upstream and downstream communication signal path. Unfortunately, these cable channel frequency allocations and designs are different in different countries of the international market. For instance, some services do not require an upstream signal path at all

When receivers are first installed, when a receiver is moved, or when there are problems with a previously operating downstream channel the receiver must establish a new valid connection. Without a known channel plan, a receiver may spend an excessive amount of time (many minutes or more) finding the desired communication channel using conventional search algorithms. If a lengthy channel initialization is encountered, the end-user or installation technician must wait for this operation to complete before continuing with use of the receiver. In addition, with an excessive initialization delay, the user may perceive the receiver to be malfunctioning or inoperable.

For example, under Euro-DOCSIS, if a 91 MHz (megahertz, or million cycles per second) to 860 MHz downstream spectrum is to be searched using

a brute force method when the channel plan and desired channel is not known, more than 3000 channel possibilities may have to be tested for the desired channel. The time necessary for the receiver to tune and its demodulator to accurately "lock" on the amplitude and phase of the signal is typically 300-1200 or more milliseconds (msec). For a 1000 msec Quadrature Amplitude Modulation (QAM) lock time, the time necessary for a conventional receiver to step through and lock on each possible frequency position in the broadband cable spectrum is significant, and can require up to a 50 minute initial search time for the receiver to find an internet connection channel.

Accordingly, there is a need for methods to enhance the channel scan initialization procedure in order to significantly reduce the time required to acquire the desired communication channel. Advantageously, such methods would enhance channel scan initialization procedures under both present and future channel plans.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURES 1a-c illustrates a cable television (CATV) signal distribution system, FIGURE 1a illustrates the signal transmission paths; FIGURE 1b illustrates a typical distribution of the a signal spectrum in a CATV signal distribution system, and FIGURE 1c illustrates some features of a channel in a CATV signal distribution system;

FIGURE 2 is a block diagram of an example of a receiver that can be utilized for channel selection in accordance with the present invention;

FIGURE 3 is a block diagram of an example of a dual conversion tuner that can be utilized as part of a receiver that can be utilized for channel selection in accordance with the present invention;

FIGURE 4 illustrates a flowchart diagram of a spectral loading characterization process in accordance with a preferred embodiment of the present invention;

FIGURE 5 illustrates how the combination of local oscillators, mixers and filters in a dual conversion tuner can be used to select a bandwidth of downstream signal;

FIGURE 6a illustrates selected signal types that can be present in a downstream spectrum while FIGURE 6b illustrates a possible constructed channel response of FIGURE 6a;

FIGURE 7 is a flowchart diagram of an example of a QAM channel check which may be used in a preferred embodiment of the present invention to; and

FIGURE 8 illustrates another embodiment of an example of a method to identify a desired channel that uses a fast Fourier transform (FFT).

DETAILED DESCRIPTION OF THE INVENTION

This invention provides receivers for broadband communications networks with improved channel search capabilities by evaluating the downstream input spectrum to identify the most probable frequency regions of the input spectrum that may contain desired channels when the overall channel plan or the region of a desired channel are not known.

A method of the present invention locates a desired downstream channel in a broad frequency spectrum input signal. This is done by generating a constructed channel response (also constructed spectrum response) from the broad frequency spectrum input signal. The constructed channel response is then processed to generate a list of prospective

channels. The channels in the prospective channel list are then checked until a desired downstream channel is identified.

Referring to the FIGURES 1a-c, and particularly to FIGURE 1a, a broadband communications network **100** transmits signals **102** between a broadband communications service provider (or "service provider" or "provider") **104** and a customer **106**. A common provider **104** of broadband communications networks **100** throughout the world are cable television companies, where the same cable transmits signals **102** for both television viewing and digital communications. For ease of explanation, the channels and the input spectrum are explained as part of a channelized cable television (CATV) system, but could be part of any channelized system.

The signals **102** from the service provider **104** to the customer **106** typically run from a headend **108** to a trunk line **110**, and from a trunk line **110** to a distribution line **112**. A drop line **114** typically connects the customer's **106** equipment (or hardware) to the distribution line **112**. The customer may connect equipment such as a television **116**, a receiver **118** such as a cable modem, set top box or telephony module to the drop line **114**. Frequently a splitter **120** is used so that the customer **106** can connect both a television **116** and a receiver **118** to the drop line **114**. The signals **102** from the customer to the service provider follow the opposite path. For simplicity of explanation, the different kinds of lines that can be present in the middle of the distribution chain between the headend **108** on the service provider's side, and the customer's **106** equipment (such as a television **116** or cable modem) on the customer's side **106** are generally omitted hereinafter.

The broadband communications network **100** will carry signals **102** in a frequency spectrum (or spectrum) **122**. The spectrum **122** for a broadband network **100** typically has a frequency range from about 5 MHz or less at the lower end **124**, to about 860 MHz presently, and possibly 1 GHz or more in the future at the upper end **126**.

Referring in particular to FIGURES 1a-c, and in particular FIGURE 1b, an "upstream" signal frequency portion of the spectrum (or upstream portion, or upstream spectrum) **128** is reserved for upstream signals **130** sent from the customer **106** to the service provider **104**. Upstream signals **130** are transmitted from the customer's **106** equipment to the headend **108** in the upstream signal frequency portion **128** of the spectrum **122**. The upstream signal frequency portion **128** of the spectrum is usually about 5-70 MHz, but can be at any frequencies carried by the network **100**. The upstream signals **130** are typically both frequency and time division multiplexed to identify individual customers **106**, but do not have to be.

"Downstream" signals **132** from the service provider **104** are sent from its headend **108** to the customers **106**, typically in a downstream frequency portion of the spectrum (or downstream portion or downstream spectrum) **134** at frequencies above about 70 MHz, but the frequencies used can be any frequencies carried by the network **100**. The downstream spectrum **134** is typically divided into channels **136** of predetermined bandwidth, which in the United States are generally 6 MHz in width, and in Europe are generally 8 MHz in bandwidth. Referring to FIGURE 1c, channels **136** are usually defined, conventionally, by the center of the frequency range included in the channel (called the center frequency or channel center) **138** and the size of

the frequency spectrum dedicated to the channel (called channel bandwidth) **140**. The present invention is not, however, limited to systems where all the channels **136** have the same channel bandwidth **140** or are designated by center frequencies **138**.

The channels **136** in the downstream spectrum **134** can carry a variety of signals of various modulation types, e.g., 64 QAM, 256 QAM, vestigial sideband (VSB)-amplitude modulation (AM), 8 VSB, 16 VSB, orthogonal frequency division multiplexing OFDM) or any other channelized modulation format, including, but not limited to 64 or 256 QAM, cable television channels, QPSK and QAM communication channels.

This invention characterizes the downstream spectrum **134**. Two embodiments are described in this disclosure, but the present invention can be present in a multitude of other embodiments, and the invention is not limited to the embodiments described herein. When the input spectrum characterization is complete, a detection algorithm is used to identify the desired downstream channel. An example of such a detection algorithm is a QAM detection algorithm used to detect QAM channels (the type of encoding used on cable modem networks currently), and the operation of the embodiments listed here are expressed in terms of detecting QAM channels, and channels on cable systems, but is not limited to such.

As illustrated in FIGURE 1a, a receiver **118** is connected to the service provider's **104** headend **108** and the customer's **106** computer system **142**. In a CATV system, the headend **108** and the receiver **118** are usually connected with a cable. For the cable any combination of coax, fiber, and fixed wireless links may be used, but typically fiber and coax both are used i.e. not just

coaxial cable. The connection between the receiver **118** and the computer system **142** is via a variety of possible connections, but typically is a 10 base T or 100 base T Ethernet, firewire IEEE 1394, or USB connection. While those are the cablings typically used for such connections, the present invention can be used with other forms of wired or unwired networks **100** suitable for carrying a frequency spectrum **122** to a receiver **118**, including but not limited to coaxial cabling, twisted pair wiring, fiber optic cabling, hybrid, coaxial/fiberoptic cabling, infrared transmitters, and over the air transmission such as with wireless LAN transmitters, and other systems known to those skilled in the art.

Illustrated in FIGURE 2 is a block diagram useful in understanding some of the elements of a commercial receiver **118**. A receiver **118** having hardware suitable for the practice of this invention is sold by Motorola Corporation under its trademark CyberSURFR. As is known to those skilled in the art, diagrams such as FIGURE 2 serve to illustrate the functions of a piece of equipment, and do not necessarily represent how hardware is embodied to carry out the tasks. It will be apparent to those skilled in the art that the functionality of the present invention can be achieved with a variety of approaches and implemented in a number of substantially equivalent ways. The present invention is not limited to the particular implementations and embodiments disclosed.

The receiver **118** has a signal input **200**. The signal input **200** conducts downstream signals **132** from the headend **108** to a physical layer **202**, which has a downstream component called the downstream physical layer **204**. The downstream physical layer comprises a downstream tuner

205 and a demodulator **208**. The downstream physical layer **204** accepts downstream input signals **132** from the headend **108** and the downstream tuner **205** processes the downstream signals **132** before providing a tuned signal **206** to the demodulator **208**. A media access controller (MAC) **210** connects the modulator **212** and the demodulator **208** to a first memory **214** and a central processing unit **216**. The central processing unit **216** is connected to a second memory **218** and a host computer physical layer **220**, which is typically an Ethernet layer. The host computer physical layer **220** sends signals to and receives signals from the host **142.**

The downstream tuner **205** processes the downstream signal **132** before the tuned signal **206** is sent to the demodulator **208**. The tuning that the downstream tuner **205** performs can include, but is not limited to, selecting a frequency range of signals to be sent to the demodulator **208**, scaling the amplitude of the signals to make good use of the amplitude range of the demodulator **208**, and shifting the frequency of the signals to occupy a frequency spectrum that the demodulator **208** operates well with.

Referring to FIGURE 3, receivers **118** typically employ automatic gain control (AGC) systems in the downstream physical layer **204** to provide constant signal levels to the demodulator **208**. FIGURE 3 includes a dual conversion tuner suitable for the present invention, but those skilled in the art will appreciate that single or multiple conversion tuners can be used with the present invention. The downstream tuner **205** selects a fixed bandwidth of the downstream signals **132** to pass on as tuned signals **206**, the width of the frequency range of the signals being passed on being the bandpass of the downstream physical tuner **205**. Although present receivers currently use

tuning electronics that select a fixed bandwidth, the present invention is not limited to such.

FIGURE 3 illustrates a simplified block diagram of an example of a downstream physical layer **300** according to a preferred embodiment of the present invention. The illustrated downstream physical layer **300** has at least one variable gain device and preferably comprises at least two variable gain devices **302, 304**, a power detector **306**, a control mechanism **308** and is connected to a microprocessor (CPU) **216** via an media access controller (MAC) **210**. Since the microprocessor **216** and MAC are not necessarily a part of the downstream physical layer, they are separated from the other components by a boundary line **324**. These components can reside in the receiver **118** as discrete components or combined components with any other compatible component of the receiver **118**. The variable gain devices **302, 304** may be attenuators or variable gain amplifiers

The downstream physical layer **300** illustrated in FIGURE 3 operates as a dual conversion receiver that has a first filter **312** and a second filter **314**, the first and second filters **312, 314** having respective associated tuning electronics, said respective associated tuning electronics being capable of being tuned independently of each other. The first and second filters **312, 314** are typically bandpass filters. In the illustrated embodiment, each filter **312, 314** is preceded by a respective mixer (first mixer and second mixer) **316 318** connected to a respective local oscillator (LO)(first local oscillator and second local oscillator) **320, 322** that shift the frequency of the downstream signal **132** to place a desired portion of the downstream stream signal within the bandpass of the respective filters **312, 314**.

Usually, because of cost considerations, the first filter **312** has a bandpass that is substantially wider than the bandwidth allocated to the channels **140** on the broadband network **100**. A bandpass of 30-40 MHz is typical for the first filter of dual conversion tuner on a receiver **118** such as the CyberSURFR modem. The second filter **314** preferably has a bandpass of about the same bandwidth as the bandwidth of the channels **136** allocated to services on the broadband network **100**. The first and second filters **312, 314** in series have a combined bandpass that allows signals having frequencies in common with the two bandpasses to pass through. This combined bandpass is the bandwidth of the downstream tuner. If the channels **136** on the broadband network **100** vary in bandwidth, either the second filter **314** should be of adjustable width, or appropriate additional tuners should be supplied with the receiver. In the United States the bandpass of the second filter **312** is normally 6 MHz, and in Europe the bandpass is normally 8 MHz.

FIGURE 4 is a flowchart that illustrates the first spectral loading characterization method. In this algorithm, a first, coarse spectral loading scan (also coarse spectral scan, coarse loading scan or coarse scan) **400** is performed. This is accomplished by tuning the downstream physical layer **204** to sample the ranges of interest of the input signal **132** between a desired lower spectrum limit **144** to a desired upper spectral limit **146.** Currently, systems for which cable modems **118** are used would have a downstream spectrum **134** of about 50-1,000 MHz, but the invention will work with other downstream spectrum **134** ranges as well.

The coarse spectral loading scan **400** is preferably accomplished by defining a set of measurements to be taken that will measure the entire

downstream spectrum **134** between the desired lower spectrum limit **144** and the desired upper spectrum limit **146**. One approach is to begin at one end of the downstream frequency spectrum **134** and serially step at a relatively broad frequency increment up or down the downstream frequency spectrum **134** toward the other end of the spectrum **134**. Preferably, the coarse frequency step **size** will be in the range of from about 1/2 the bandwidth of the downstream tuner (which, in a dual conversion tuner, may be a combined bandpass or more commonly, the bandwidth of the second filter), to about twice the bandwidth of the downstream tuner, and most preferably corresponding to the downstream tuner's bandwidth. For each measurement of the set of measurements, the channel power is measured and can be stored in memory 218.

The channel power can be measured using the power measurement capabilities of the receiver **118** that are standard in such receivers currently. In the embodiment illustrated in FIGURE 3, the power detector (or detector) **306** and the control mechanism **308** reside in the demodulator **208**, but may be located elsewhere in the receiver **118**. The power detector **306** provides a means to measure the incoming signal level of the selected "coarse" or "fine" input frequency range to the detector **308** provided by the downstream physical layer **204**. The power level is also used as part of a feedback variable gain control mechanism to set a desired signal level into the demodulator **208** as part of an automatic gain control (AGC) system **300**.

It should be noted that the time required to measure channel power can be significantly less than the time required to determine whether a channel is a desired channel by other methods. In the case of a typical cable

modem **118**, the time to perform a QAM lock test is substantially longer than the time required to do a power measurement. A typical power measurement using present hardware can take about 6ms while a QAM lock test using current QAM lock circuitry can take about 1000ms. This time difference provides significant improvement in channel search time in accordance with the present invention. The power measurement feature utilized in the present invention is typically included in conventional receivers **118** for other purposes such as diagnostics, network management, and automatic gain control feed back. To obtain the minimum time for channel power measurement, the receiver may be optimally configured for this purpose. For example, the AGC loop bandwidth may be increased for the channel power measurement. In a receiver **118** such as the CyberSURFR modem the AGC loop bandwidth can be set by a register contained within the demodulator's "AGC Control Mechanism."

Another step in the first algorithm is to determine the power containing regions **402** of the downstream spectrum from the results of the coarse spectral loading scan **400**. This is done by identifying a number of regions, K, where power above a threshold standard is detected. The set of measurements to detect power constitutes a power spectrum, and the frequency spectrum covered by the set of measurements where power is detected are power containing regions of the power spectrum, or power containing regions for short. Either the power spectrum, or just the power containing regions, can be recorded in digital memory, and can be processed to select potential frequency ranges for the desired channel. For example, this coarse scan may determine that based on a predetermined threshold, for

instance, -15dBmV, that no channels are present over one or more power lacking regions (regions not meeting the predetermined threshold) of the power spectrum (e.g., regions totaling, say, 550 MHz in a particular system). Ultimately, this information will reduce the search time for the desired downstream channel because these power lacking regions need not be searched.

Referring again to FIGURE 4, another step in the first spectral characterization approach is a finer spectrum scan **404** which is performed over the at least the power containing regions. The finer spectrum scan **404** has a finer resolution, that is more data points over the same spectral regions as the coarse scan **400**. While the finer spectrum scan can be done by performing measurements that have overlapping spectral ranges or by performing measurements that have narrower spectral ranges than the coarse scan or by performing scans that do both, the present invention can work with a wide variety of methods for taking a finer spectrum scan that will be apparent to those skilled in the art.

The bandwidth covered by a measurement can be reduced **406** (or narrowed) if a dual or multiple conversion tuner is being used. . Reduction of the measurement bandwidth in a dual or multi conversion tuner can be easily accomplished without added circuitry in the unique manner as described below. However, this does not mean that such measurement bandwidth narrowing is exclusive to dual/multi tuners. It can be accomplished in a single conversion tuner by switching in a narrow bandwidth filter in place of filter 314, by switching in an additional bandpass filter, limiting amp 304 bandwidth, or by other methods known to those skilled in the art.

As described above, such tuners have at least a first filter **312** and second filter **314** that can be used in an unconventional way to narrow the frequency range for a signal power measurement. As illustrated in FIGURE 5a, the mixers **316, 318** and respective local oscillators **320, 322,** cooperate such that the signal frequencies passing through the second filter **502** are normally located entirely within the signal frequencies passing through the first filter **500** resulting in a first net bandpass **506** such that an entire channel's signal passes through both filters. Alternatively, as illustrated in FIGURE 5b, however, the frequencies passed through the pair of filters **312, 314** can be reduced by having the oscillators **316, 318** and mixers **320, 322** positioning the center of the bandpass **508** of the second filter **314** at the "edge" of the bandpass of the first filter **312**. The resultant second net bandpass **510** is narrower than the bandpass of either filter. Usually, this is accomplished by offsetting the second local oscillator frequency from its normal value. Although more precise results may be obtained with this offset technique, it is not required by this invention.

Returning to FIGURE 4, with or without the bandwidth reduction or narrowing, a fine spectral loading scan (or fine scan) **404** can be performed by scanning the power containing regions at a finer frequency increment than the original course scan increment. The downstream physical layer **204** is methodically tuned to each test frequency range where the input power is measured and stored in memory.

For example, for a European DOCSIS cable system, the coarse scan **400** may be performed with 8 MHz intervals to determine power containing spectral regions **402** with power containing or power lacking channels. In

another step, a higher frequency resolution (fine or relatively finer or finer resolution) scan **404** can be performed using a smaller frequency interval, which is less than one half, the frequency interval of the coarse scan, for example, about 2 MHz. In each case, channel power is measured and stored in memory for each measurement of the set of measurements. The set of measurements is a constructed channel response.

After the power levels of the power containing spectral regions have been quantified by the fine scan **404**, potential desired channels are identified via an off-line processing operation **408**. The input spectrum characterization may be performed by the microprocessor **216**. Referring to FIGURE 6, this offline processing operation **408** "views" the constructed channel response obtained during the fine resolution scan to identify features such as NTSC video carriers **600**, QAM signals **602**, and voids **604**.

By using pattern matching techniques, a large variety of which are known in the art, channel content can be tentatively identified without actually having to establish a lock on the signal. The offline processing operation **408** characterizes the constructed channel response. One way of conducting the offline processing operation determines the signal type, bandwidth, and center frequency, but many different techniques may be derived for this purpose. For example, a simple approach in determining the center frequency and bandwidth of the incoming signal involves an analysis of the minimum ("valley") and maximum ("peaks") values of the constructed spectrum response.

Referring to FIGURES 6 a-b, it can be seen that peaks **606** and valleys **608** are present. By cataloging these peaks **606** and valleys **608**, and

calculating the frequency differences between peaks **610** as well as the frequency differences between valleys **612**, it can be surmised that it is quite likely that 6 MHz bandwidth signals are present. In addition, the absolute frequency of the valleys **614** or peaks **616** give indications to the actual center frequency **618** of the measured channel **620**. Further analysis of the constructed spectrum response can give indications of the signal type.

For example, as can be seen in FIGURES 6a-b, a downstream QAM signal **602** compared to a NTSC analog video signal **600** has a much more uniform amplitude response. In the example of FIGURE 6b, the shape of the constructed signal within one 6 MHz wide region **618** defined by two valleys **614** tends to have an asymmetrical peaking response with more spectral energy in the leftmost area **626** of the assumed channel. It can be surmised that this response shape was generated from the corresponding analog video NTSC signal shown above it in FIGURE 6a.

In order to enable signal type determination, pattern matching and correction techniques are used. For example, a simple shape mask could be used to sort NTSC signals **600** from QAM signals **602**. A mask for each signal type must first be created representing the typical spectral properties of each signal. Next, the constructed spectrum response is divided into prospective channels by methods as previously described (including, but limited to peak and valley analysis). Each constructed channel response can be normalized to aid in comparison to the predefined signal mask. At this point, one of any number of standard or custom defined correlation methods known to those skilled in the art can be applied. Correlation to each mask is attempted resulting in "scored" responses. After completing a cross-

correlation operation, a determination of the recovered signal type can be made based on the correlation results.

As a result of the pattern matching technique above, a list of prospective desired channels is generated. Preferably, this list is generated by identifying the center frequencies and bandwidths of the channels **136**. The number of prospective channels in this list can be very small compared to the total number of possible channels (5-100, versus 3000, for example) for the desired channel's signal. With a channel power measurement time of 6 msec, all power measurements required in the algorithm of FIGURE 4 may be performed in less than 2 seconds.

FIGURE 7 illustrates a standard channel check algorithm that can be performed on each of the prospective desired channels until the desired downstream channel is located. For purposes of illustration, a QAM check algorithm has been illustrated because QAM encoding is the type used for cable modems. The invention is not, however, limited to QAM encoding. A prospective channel is selected and the downstream physical layer **204** is configured **700** to present that channel's tuned signal **206** to the demodulator **208**. In another step, the receiver **118**, usually through its demodulator **208**, checks if it can lock on to the desired channel **702**. If it can, then the receiver **118**, usually through its media access controller **210**, can check for a forward error correction (FEC) lock **704**. Further, the can check for MPEG packetization synchronization **706**. In another step, the receiver, usually through its media access controller, checks for recognized downstream MAC SYN messages, and if such messages are found, identifies the channel as a valid QAM channel. If the channel is valid, then procedures appropriate to

having found a valid QAM channel are performed **708** which will depend on the system (with or without termination of the search), or if the channel was not a valid QAM channel, the next prospective channel in the list is checked **710**.

FIGURE 8 is a flowchart of an alternate QAM identification method that can be used in place of the method of FIGURE 4. As in the method of FIGURE 4, the same coarse spectral loading characterization **800** can be performed. The amount of processing required in the later steps of this procedure can be reduced by determining the power containing regions of the spectrum **802**. The receiver can then be configured **804** to perform a spectral analysis operation, preferably, as illustrated, a fast Fourier transform (FFT). The spectral analysis operation would usually be performed in the demodulator. Thereafter, for each power containing spectral region, a constructed channel response is determined by means of a spectrum analysis operation **806** performed by the receiver, usually in the demodulator. Although the FFT method is illustrated and preferred, other spectrum analysis methods will be apparent to those skilled in the art and are also part of the present invention.

After each of the power containing spectral regions are characterized as described above, a more complete spectral response of the power containing regions of the spectrum can be constructed **808** by combining the individual spectrum analyses to make up a larger response. Reference amplitudes of the spectral analysis responses can be determined by the power measurements made in the coarse spectral scan operation. These reference amplitudes can be used to calibrate the spectral analyses so that

adjacent spectrum analyses can be combined to form larger spectrum analyses. Preferably, all adjacent power containing regions are combined to construct contiguous power containing regions.

Although these spectral analyses are performed on contiguous, non-overlapping portions of the downstream spectrum, the measurements can also be performed by overlapping the regions covered by individual spectrum analysis operations. When the spectral analyses overlap in the downstream spectrum, the overlapping portions can be used to scale the regions relative to one another to calibrate the entire spectrum as will be apparent to those skilled in the art.

Within the fully constructed power containing portion of the spectrum, prospective desired channels are identified and a list of these channel centers and bandwidths is generated, and may be stored in the microprocessor memory. Optionally, the shape of the spectrum of channels identified as desired channels can be analyzed to determine if the prospective desired channel has the width and shape of the desired channel, and unsuitable channels removed from the list.

Like the process in FIGURE 4 **408**, after the channel power spectrum characterization data is collected, it is interpreted by an algorithm (preferably implemented via a microprocessor) with embedded software that in turn identifies prospective cable channel frequencies for selective testing for specific desired channel identification. The algorithm identifies potential desired channels (in the illustrated embodiment, QAM channels) based on analyzing the reconstructed total spectrum response **808.**

EXAMPLES

Example 1 - Analysis By Fine Increment Power Scan

The broadband network provides a downstream signal in the downstream frequency spectrum of 46 MHz to 854 MHz. Within that downstream signal, at an unknown frequency, is a 64 QAM channel used for digital communication. The broadband network is connected to a receiver. The desired channel is a 64 QAM channel with a bandwidth of 8 MHz centered at 710 MHz.

The receiver can perform a coarse spectral loading scan by measuring the downstream frequency spectrum beginning with a series of power measurements that measure a bandwidth of 8 MHz each. A power detector in the receiver performs the power measurements. The first measurement can have a bandwidth of 8 MHz and a center at 50 MHz, and cover the spectrum from 46 MHz to 54 MHz. Successive measurements will have bandwidths of 8 MHz and centers with increments 8 MHz higher than the previous measurement. The one hundredth measurement will have a center at 850 MHz and cover the spectrum from 846 MHz to 854 MHz. The power measurements can be stored in memory.

A microprocessor can then determine whether the power measurements stored in memory surpass a power threshold of –15dBmV. The microprocessor then identifies contiguous regions containing power. For the purposes of this example, the regions from 46-454 MHz, 606-694 MHz, and 706-714 MHz are found to contain power.

The receiver then scans the first power containing region at a bandwidth of 8 MHz, with an increment of 2 MHz. The first measurement will

be centered at 40 MHz, the second at 56 MHz, and so on until the last measurement is centered at 460 MHz. An offline processing operation will then examine the result of the finer incremented power scan to identify regions where a 64 QAM channel can be found and generate a list of possible desired channel frequency centers and bandwidths. No possible channels are found.

The receiver then scans the second power containing region at a bandwidth of 8 MHz, with an increment of 2 MHz. The first measurement of the second set will be centered at 600 MHz, the second at 602 MHz until the last is centered at 700 MHz. An offline processing operation again examines the results to see if the shape of the power measurements could be consistent with a 64 QAM channel. The offline processing operation identifies three possible 64 QAM channels centered at 674 MHz, 682 MHz, and 690 MHz.

The receiver then scans the third power containing region at a bandwidth of 8MHz starting at 700 MHz and running to 720 MHz in increments of 2 MHz. The ensuing offline processing operation identifies the channel as a possible QAM channel.

A 64 QAM check algorithm is then performed. The downstream physical layer is configured to receive an 8 MHz wide channel at 674.5 MHz. The demodulator then attempts to establish a QAM lock, that is, whether it can identify signals located at the proper patterns of amplitude and phase for that kind of signal. The lock fails.

A 64 QAM check algorithm is also attempted on the channel at 682.5 MHz, and succeeds. The demodulator of the receiver then tries to establish a forward error correction (FEC) lock. The lock fails.

A 64 QAM check algorithm is then attempted on the channel at 690.5 MHz, and succeeds, and the FEC lock also succeeds. The demodulator checks for MPEG packetization synchronization and fails.

A 64 QAM check algorithm is then attempted on the channel at 710.5 MHz. The QAM lock, FEC lock, and MPEG packetization synchronization all succeed. The media access controller checks for MAC SYN messages. When the media access controller recognizes a MAC SYN message, the channel at 710.5 MHz is identified as valid, and the desired channel has been found.

Example 2 - Analysis By Fine Increment Power Scan In 250 kHz Steps

To better identify each potential QAM channel's center, the search is done as in Example 1, except that the local oscillators of the downstream tuner are set so that only 250 kHz of downstream signal passes through both filters. Then each of the prospective channels at 674, 682, 690 and 710 MHz is scanned in steps of 250 kHz. The finer scan finds that the shape of the channel at 674 MHz is not as consistent with 64 QAM as the others and that channel is placed at the end of the prospective channel list. The number of potential QAM channels (L) is 4. Optionally, the channel at 674 MHz could just as easily be deleted from the prospective channel list, reducing L to 3.

Example 3 - Analysis by Fast Fourier Transform

Alternatively, the receiver can be provided with firmware or hardware fast Fourier transform (FFT) capability. To better identify each potential QAM channel's center and the shape of each signal, the search is done as in Example 1, except that the local oscillators of the downstream tuner are set so that the full bandwidth of the downstream tuner passes

through. A fast Fourier transform is then performed on the signal received. The downstream tuner is then set to select another section of the downstream signal and another fast Fourier transform is performed on that section of the downstream signal. This is done for the full spectrum of interest, with the separate scans being scaled by the results of the coarse power scan measurements. These scaled results are combined to provide a complete picture of the power-containing portions of the downstream spectrum. This results in an even finer resolution than even the 250KHz bandwidth power scan, and finds that the shape of the channel at 674 MHz is not consistent with 64 QAM and deletes it from the prospective channel list, reducing L to 3.

Example 4 - Analysis by Fast Fourier Transform with Alternative Scaling

The fast Fourier channel scan of Example 3 can be performed by overlapping the scans by 1/4 of the bandwidth of the downstream tuner. The overlapping sections can be compared and scaled against each other to provide a complete picture of the power containing portions of the downstream spectrum.

While the invention has been described in conjunction with a specific embodiment thereof, additional advantages and modifications will readily occur to those skilled in the art. The invention, in its broader aspects, is therefore not limited to the specific details, representative apparatus, and illustrative examples shown and described. Various alterations, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Thus, it should be understood that the invention is not limited by the foregoing description, but embraces all such alterations,

modifications and variations in accordance with the spirit and scope of the appended claims.